

MEASUREMENT COMPUTING

PCI-DAS1602/16

Analog and Digital I/O Board

User's Guide



**MEASUREMENT
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About this User's Guide

What you will learn from this user's guide

This user's guide explains how to install, configure, and use the PCI-DAS1602/16 board so that you get the most out of its analog, digital, and timing I/O features.

This user's guide also refers you to related documents available on our web site, and to technical support resources.

Conventions in this user's guide

The following conventions are used in this manual to convey special information:

For more information on ...

Text presented in a box signifies additional information and helpful hints related to the subject matter you are reading.

Caution! Shaded caution statements present information to help you avoid injuring yourself and others, damaging your hardware, or losing your data.

<#.#> Angle brackets that enclose numbers separated by a colon signify a range of numbers, such those assigned to registers, bit settings, etc.

bold text **Bold** text is used for the names of objects on the screen, such as buttons, text boxes, and check boxes. For example:
1. Insert the disk or CD and click the **OK** button.

italic text *Italic* text is used for the names of manuals and help topic titles, and to emphasize a word or phrase. For example:
▪ The *InstaCal* installation procedure is explained in the *DAQ Software Quick Start*.
▪ *Never* touch the exposed pins or circuit connections on the board.

Where to find more information

The following electronic documents provide helpful information relevant to the operation of the PCI-DAS1602/16.

- MCC's *Specifications: PCI-DAS1602/16* (the PDF version of Chapter 6 in this guide) is available on our web site at www.mccdaq.com/pdfs/PCI-DAS1602-16.pdf.
- MCC's *Register Map for the PCI-DAS1602/16 Series* is available on our web site at www.mccdaq.com/registermaps/RegMapPCI-DAS1602-16.pdf.
- MCC's *DAQ Software Quick Start* is available on our web site at www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf.
- MCC's *Guide to Signal Connections* is available on our web site at www.mccdaq.com/signals/signals.pdf.
- MCC's *Universal Library User's Guide* is available on our web site at www.mccdaq.com/PDFmanuals/sm-ul-user-guide.pdf.
- MCC's *Universal Library Function Reference* is available on our web site at www.mccdaq.com/PDFmanuals/sm-ul-functions.pdf.
- MCC's *Universal Library for LabVIEW™ User's Guide* is available on our web site at www.mccdaq.com/PDFmanuals/SM-UL-LabVIEW.pdf.

This user's manual is also available on our web site at www.mccdaq.com/PDFmanuals/PCI-DAS1602-16.pdf.

Introducing the PCI-DAS1602/16

Overview: PCI-DAS1602/16 features

The PCI-DAS1602/16 multifunction analog and digital I/O board sets a new standard for high performance data acquisition on the PCI bus. This manual explains how to install and use the PCI-DAS1602/16 board.

The PCI-DAS1602/16 is a multifunction measurement and control board designed for the PCI bus. This board can be used for applications such as data acquisition, system timing, and industrial process control.

The PCI-DAS1602/16 board is completely plug and play, with no switches, jumpers or potentiometers to set. All board addresses and interrupt sources are set with software. You calibrate the board with software that uses programmable on-board digital potentiometers and trim D/A converters.

The PCI-DAS1602/16 provides the following features:

- Eight differential or 16 single-ended 16-bit analog inputs
- Sample rates of up to 200 kHz
- 24 bits of high-drive digital I/O
- Three 16-bit down counters
- 100-pin high density I/O connector
- Two FIFO buffered 16-bit analog outputs with update rates of up to 100 kHz

Analog input ranges are selectable via software as bipolar or unipolar. Bipolar input ranges are $\pm 10\text{V}$, $\pm 5\text{V}$, $\pm 2.5\text{V}$ and $\pm 1.25\text{V}$. Unipolar input ranges are 0 to 10V, 0 to 5V, 0 to 2.5V and 0 to 1.25V. The PCI-DAS1602/16 has an analog trigger input. The trigger level and direction are software configurable.

The PCI-DAS1602/16 board has two 82C54 counter chips. Each chip contains three 16-bit down counters that provide clock, gate, and output connections.

Software features

The following software ships with the PCI-DAS1602/16 free of charge.

- *InstaCal* installation, calibration, and test utility
- TracerDAQ™ suite of virtual instruments
- SoftWIRE® for Visual Studio® .NET graphical programming
- MCC DAQ Components for VS .NET (installed with SoftWIRE® for VS .NET)

For information on the features of *InstaCal*, TracerDAQ, and SoftWIRE, refer to the *DAQ Software Quick Start* booklet that shipped with the PCI-DAS1602/16.

Installing the PCI-DAS1602/16

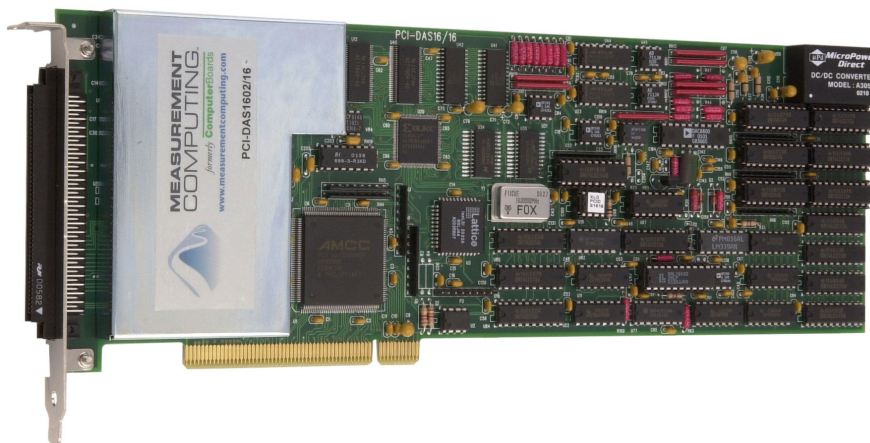
What is included with your PCI-DAS1602/16

As you unpack your board, make sure each of the items shown below is included:

Standard components

The following items should be included with your shipment:

- PCI-DAS1602/16 board



Software

The *Measurement Computing Data Acquisition Software* CD contains the following software:

- InstaCal installation, calibration, and test utility
- TracerDAQ suite of virtual instruments
- SoftWIRE for VS .NET
- SoftWIRE MCC DAQ Components for .NET



Documentation

In addition to this hardware user's guide, you should also receive the *DAQ Software Quick Start* (available in PDF at www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf). Please read this booklet completely before installing any software and hardware.



Optional components

You can also order the following MCC products to use with your PCI-DAS1602/16.

Cables

- C100FF-*x* cable



Signal termination and conditioning accessories

MCC provides signal conditioning and termination products for use with the PCI-DAS1602/16. Refer to [Field wiring and signal termination](#) on page 2-7 for a complete list of compatible accessory products.

If any items are missing or damaged, notify Measurement Computing Corp. immediately by phone, fax, or e-mail:

- Phone: 508-946-5100 and follow the instructions for reaching Tech Support.
- Fax: 508-946-9500 to the attention of Tech Support
- Email: techsupport@measurementcomputing.com

Unpacking the board

The PCI-DAS1602/16 board is shipped in an antistatic container to prevent damage by an electrostatic discharge. To avoid such damage, perform the following procedure when unpacking and handling your board.

1. Before opening the antistatic container, ground yourself with a wrist-grounding strap or by holding onto a grounded object (such as the computer chassis).
2. Touch the antistatic container to the computer chassis before removing the board from the container.
3. Remove the board from the container. *Never* touch the exposed pins or circuit connections on the board.

If your board is damaged, notify Measurement Computing Corporation immediately by phone, fax, or e-mail. For international customers, contact your local distributor where you purchased the board.

- Phone: 508-946-5100 and follow the instructions for reaching Tech Support.
- Fax: 508-946-9500 to the attention of Tech Support
- Email: techsupport@measurementcomputing.com

Installing the software

Install the software included with your board *before* you install the hardware. Installing the software first ensures that the information required for proper board detection is installed and available at boot up.

Refer to the *DAQ Software Quick Start* for instructions on installing the software on the *Measurement Computing Data Acquisition Software CD*. This booklet is shipped with the hardware, and is also available in PDF at www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf.

Installing the hardware

The PCI-DAS1602/16 board is completely plug-and-play. There are no switches or jumpers to set on the board. Configuration is controlled by your system's BIOS. To install your board, follow the steps below.

Install the MCC DAQ software before you install your board

The driver needed to run your board is installed with the MCC DAQ software. Therefore, you need to install this software before you install your board. Follow the directions for installing this software in the *DAQ Software Quick Start* shipped with your board.

1. Turn your computer off, open it up, and insert your board into an available PCI slot.
2. Close your computer and turn it on.

If you are using an operating system with support for plug-and-play (such as Windows 2000 or Windows XP), a dialog box pops up as the system loads indicating that new hardware has been detected. If the information file for this board is not already loaded onto your PC, you will be prompted for the disk containing this file. The MCC DAQ software contains this file. If required, insert the *Measurement Computing Data Acquisition Software CD* and click **OK**.

3. To test your installation and configure your board, run the *InstaCal* utility installed in the previous section. Refer to the *DAQ Software Quick Start* that came with your board for information on how to initially set up and load *InstaCal*.
4. If your board has been powered-off for more than 10 minutes, allow your computer to warm up for at least 15 minutes before acquiring data with this board. This warm-up period is required for the board to achieve its rated accuracy. The high speed components used on the board generate heat, and it takes this amount of time for a board to reach steady state if it has been powered off for more than 10 minutes.

Configuring the hardware

All hardware configuration options on the PCI-DAS1602/16 are software controlled. You can select some of the configuration options using *InstaCal*, such as the analog input configuration (16 single-ended or eight differential channels), the edge used for triggering when using an external pacer, and the counter source. Once selected, any program that uses the Universal Library initializes the hardware according to these selections.

Connecting the board for I/O operations

Connectors, cables – main I/O connector

Table 2-1 lists the board connectors, applicable cables, and compatible accessory products for the PCI-DAS1602/16.

Table 2-1. Board connector, cables, and accessory equipment

Connector type	100-pin high-density Robinson-Nugent	
Compatible cables	C100FF-x	
Compatible accessory products with the C100FF-x cable	ISO-RACK16/P ISO-DA02/P BNC-16SE BNC-16DI CIO-MINI50 CIO-TERM100	SCB-50 SSR-RACK24 (DADP-5037 adaptor required) SSR-RACK08 (DADP-5037 adaptor required) CIO-ERB24 (DADP-5037 adaptor required) CIO-ERB08 (DADP-5037 adaptor required) CIO-SERB08 (DADP-5037 adaptor required)

The PCI-DAS1602/16 board's main I/O connector is a 100-pin high density connector labeled **J1**. All signals pass through this connector. The pinout for eight-channel differential mode is listed in Table 2-2 on page 2-5. The pinout for 16-channel single ended mode is listed in Table 2-3 on page 2-6.

Information on signal connections

General information regarding signal connection and configuration is available in the *Guide to Signal Connections* (available at www.mccdaq.com/signals/signals.pdf).

Caution! When connecting a cable to the board's I/O connector, make sure that the arrow indicating pin 1 on the board connector lines up with the arrow indicating pin 1 on the cable connector. Connecting cables can damage the board and the I/O controller.

Pinout – main I/O connector

Table 2-2. 8-channel differential mode pin out

Signal Name	Pin		Pin	Signal Name
GND	100	■ ■	50	GND
EXTERNAL INTERRUPT	99	■ ■	49	SSH OUT
N/C	98	■ ■	48	PC +5 V
EXTERNAL D/A PACER GATE	97	■ ■	47	N/C
D/A INTERNAL PACER OUTPUT	96	■ ■	46	N/C
A/D INTERNAL PACER OUTPUT	95	■ ■	45	A/D EXTERNAL TRIGGER IN
N/C	94	■ ■	44	D/A EXTERNAL PACER IN
N/C	93	■ ■	43	ANALOG TRIGGER IN
-12 V	92	■ ■	42	A/D EXTERNAL PACER
GND	91	■ ■	41	CTR 4 OUT
+12 V	90	■ ■	40	CTR 4 GATE
GND	89	■ ■	39	CTR 4 CLK
N/C	88	■ ■	38	D/A OUT 1
N/C	87	■ ■	37	D/A GND 1
N/C	86	■ ■	36	D/A OUT 0
N/C	85	■ ■	35	D/A GND 0
N/C	84	■ ■	34	N/C
N/C	83	■ ■	33	N/C
N/C	82	■ ■	32	N/C
N/C	81	■ ■	31	N/C
N/C	80	■ ■	30	N/C
N/C	79	■ ■	29	N/C
N/C	78	■ ■	28	N/C
N/C	77	■ ■	27	N/C
N/C	76	■ ■	26	N/C
N/C	75	■ ■	25	N/C
FIRSTPORTC Bit 7	74	■ ■	24	N/C
FIRSTPORTC Bit 6	73	■ ■	23	N/C
FIRSTPORTC Bit 5	72	■ ■	22	N/C
FIRSTPORTC Bit 4	71	■ ■	21	N/C
FIRSTPORTC Bit 3	70	■ ■	20	N/C
FIRSTPORTC Bit 2	69	■ ■	19	N/C
FIRSTPORTC Bit 1	68	■ ■	18	LLGND
FIRSTPORTC Bit 0	67	■ ■	17	CH7 LO
FIRSTPORTB Bit 7	66	■ ■	16	CH7 HI
FIRSTPORTB Bit 6	65	■ ■	15	CH6 LO
FIRSTPORTB Bit 5	64	■ ■	14	CH6 HI
FIRSTPORTB Bit 4	63	■ ■	13	CH5 LO
FIRSTPORTB Bit 3	62	■ ■	12	CH5 HI
FIRSTPORTB Bit 2	61	■ ■	11	CH4 LO
FIRSTPORTB Bit 1	60	■ ■	10	CH4 HI
FIRSTPORTB Bit 0	59	■ ■	9	CH3 LO
FIRSTPORTA Bit 7	58	■ ■	8	CH3 HI
FIRSTPORTA Bit 6	57	■ ■	7	CH2 LO
FIRSTPORTA Bit 5	56	■ ■	6	CH2 HI
FIRSTPORTA Bit 4	55	■ ■	5	CH1 LO
FIRSTPORTA Bit 3	54	■ ■	4	CH1 HI
FIRSTPORTA Bit 2	53	■ ■	3	CH0 LO
FIRSTPORTA Bit 1	52	■ ■	2	CH0 HI
FIRSTPORTA Bit 0	51	■ ■	1	LLGND

PCI slot ↓

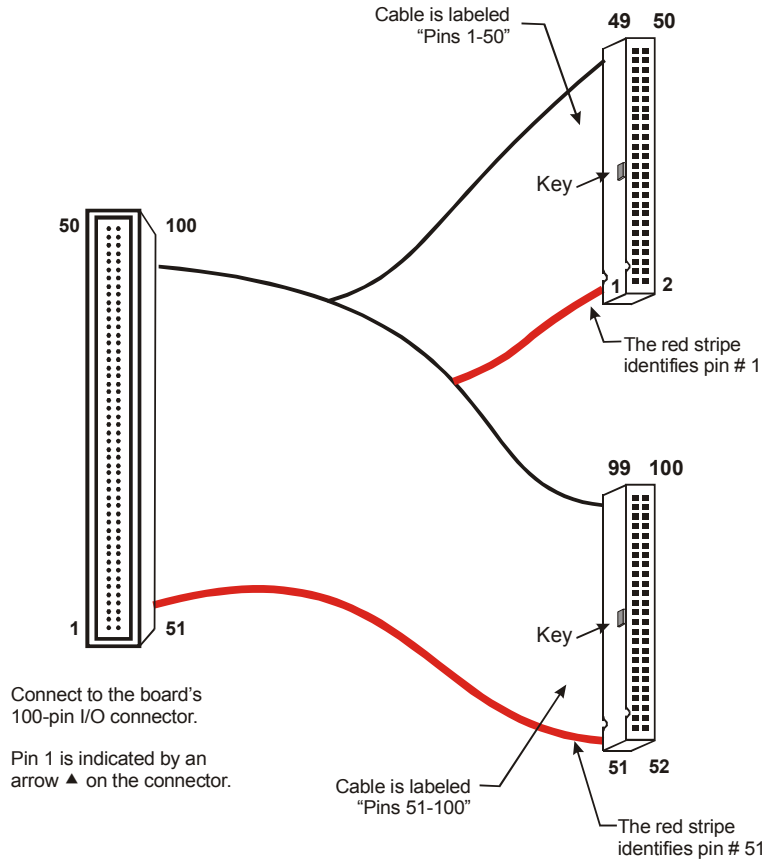
Table 2-3. 16-channel single-ended mode pin out

Signal Name	Pin		Pin	Signal Name
GND	100	■ ■	50	GND
EXTERNAL INTERRUPT	99	■ ■	49	SSH OUT
N/C	98	■ ■	48	PC +5 V
EXTERNAL D/A PACER GATE	97	■ ■	47	N/C
D/A INTERNAL PACER OUTPUT	96	■ ■	46	N/C
A/D INTERNAL PACER OUTPUT	95	■ ■	45	A/D EXTERNAL TRIGGER IN
N/C	94	■ ■	44	D/A EXTERNAL PACER IN
N/C	93	■ ■	43	ANALOG TRIGGER IN
-12 V	92	■ ■	42	A/D EXTERNAL PACER
GND	91	■ ■	41	CTR 4 OUT
+12 V	90	■ ■	40	CTR 4 GATE
GND	89	■ ■	39	CTR 4 CLK
N/C	88	■ ■	38	D/A OUT 1
N/C	87	■ ■	37	D/A GND 1
N/C	86	■ ■	36	D/A OUT 0
N/C	85	■ ■	35	D/A GND 0
N/C	84	■ ■	34	N/C
N/C	83	■ ■	33	N/C
N/C	82	■ ■	32	N/C
N/C	81	■ ■	31	N/C
N/C	80	■ ■	30	N/C
N/C	79	■ ■	29	N/C
N/C	78	■ ■	28	N/C
N/C	77	■ ■	27	N/C
N/C	76	■ ■	26	N/C
N/C	75	■ ■	25	N/C
FIRSTPORTC Bit 7	74	■ ■	24	N/C
FIRSTPORTC Bit 6	73	■ ■	23	N/C
FIRSTPORTC Bit 5	72	■ ■	22	N/C
FIRSTPORTC Bit 4	71	■ ■	21	N/C
FIRSTPORTC Bit 3	70	■ ■	20	N/C
FIRSTPORTC Bit 2	69	■ ■	19	N/C
FIRSTPORTC Bit 1	68	■ ■	18	LLGND
FIRSTPORTC Bit 0	67	■ ■	17	CH15 HI
FIRSTPORTB Bit 7	66	■ ■	16	CH7 HI
FIRSTPORTB Bit 6	65	■ ■	15	CH14 HI
FIRSTPORTB Bit 5	64	■ ■	14	CH6 HI
FIRSTPORTB Bit 4	63	■ ■	13	CH13 HI
FIRSTPORTB Bit 3	62	■ ■	12	CH5 HI
FIRSTPORTB Bit 2	61	■ ■	11	CH12 HI
FIRSTPORTB Bit 1	60	■ ■	10	CH4 HI
FIRSTPORTB Bit 0	59	■ ■	9	CH11 HI
FIRSTPORTA Bit 7	58	■ ■	8	CH3 HI
FIRSTPORTA Bit 6	57	■ ■	7	CH10 HI
FIRSTPORTA Bit 5	56	■ ■	6	CH2 HI
FIRSTPORTA Bit 4	55	■ ■	5	CH9 HI
FIRSTPORTA Bit 3	54	■ ■	4	CH1 HI
FIRSTPORTA Bit 2	53	■ ■	3	CH8 HI
FIRSTPORTA Bit 1	52	■ ■	2	CH0 HI
FIRSTPORTA Bit 0	51	■ ■	1	LLGND

PCI slot ↓

The signal names for pins 2 to 17 define the functions for both single-ended modes and also for differential input modes. For example, if you are using eight differential inputs, pin 2 is the high side of channel 0 (CH0 HI) and pin 3 is the low side (CH0 LO) of channel 0. If you are using single-ended inputs, pin 2 is channel 0 (CH0 HI), but pin 3 is now channel 8 (CH8 HI). When you use single-ended inputs, use LLGND (and not GND) for analog signal returns.

You can use a C100FF-x cable to connect signals to the PCI-DAS1602/16 board. The C100FF-x cable is made up of two 50-pin ribbon cables that are joined at one end with a 100-pin connector. The two 50-pin cables diverge and are terminated at the other end with standard 50-pin header connectors.



The first 50-pin connector is used primarily for analog signals (pins 1-50 on the 100-pin connector). The second 50-pin connector is used primarily for digital signals (pins 51-100 on the 100-pin connector). This configuration minimizes noise in the analog signal lines, and greatly simplifies field wiring and connections to external devices. You can purchase C100FF-*x* series cables from our web site at <http://www.mccdaq.com>.

Field wiring and signal termination

You can use the following MCC screw terminal boards to terminate field signals and route them into the PCI-DAS1602/16 board using the C100FF-*x* cable:

Screw terminal boards

- **CIO-TERM100** – 100 pin, 16 x 4 screw terminal board. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbipproduct.asp?dept_id=102&pf_id=281.
- **CIO-MINI50** – 50-pin universal screw terminal accessory. Two boards are required. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbipproduct.asp?dept_id=102&pf_id=258.
- **SCB-50** – 50-conductor, shielded signal connection/screw terminal box that provides two independent 50-pin connections. Only one box is required. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbipproduct.asp?dept_id=196&pf_id=1168.

BNC connector interface boxes

- **BNC-16SE** – 16-channel single-ended BNC connector box. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbipproduct.asp?dept_id=101&pf_id=713.
- **BNC-16DI** – Eight-channel differential BNC connector box. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbipproduct.asp?dept_id=101&pf_id=714.

Analog signal conditioning and expansion

- **ISO-RACK16/P** – 16-channel isolation module mounting rack. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbiproduct.asp?dept_id=127&pf_id=1111.
- **ISO-DA02/P** – Two-channel, 5B module rack. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbiproduct.asp?dept_id=128&pf_id=710.

Digital signal conditioning

The following digital signal conditioning products have 37-pin connectors. Use the DADP-5037 adaptor board for connections to the C100FF-x cable's 50-pin connectors. Details on this adaptor board are available on our web site at www.mccdaq.com/cbicatalog/cbiproduct.asp?dept_id=103&pf_id=1381.

- **SSR-RACK24** – 24-position solid state relay rack. The DADP-5037 adaptor board is required. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbiproduct.asp?dept_id=122&pf_id=1193.
- **SSR-RACK08** – Eight-channel solid state relay rack. The DADP-5037 with TN-MC78M05CT adaptor board is required. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbiproduct.asp?dept_id=122&pf_id=620.
- **CIO-ERB24** – 24-channel electromechanical relay accessory for digital I/O boards. The DADP-5037 adaptor board is required. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbiproduct.asp?dept_id=123&pf_id=241.
- **CIO-ERB08** – Eight-channel electromechanical relay accessory for digital I/O boards. The DADP-5037 adaptor board is required. Details on this product are available on our web site at www.mccdaq.com/cbicatalog/cbiproduct.asp?dept_id=123&pf_id=240.

Caution! Before connecting signals to the PCI-DAS1602/16, measure the voltage between ground at the signal source and ground at the PC. If you measure >10 volts, do not connect the board to this signal source, as you are beyond the usable input range of the board. Either adjust your grounding system or add isolation signal conditioning to take useful measurements. A ground offset voltage of more than 30 volts may damage the board and possibly your computer. An offset voltage much greater than 30 volts will damage your electronics, and may be hazardous to your health.

To terminate signals and route them into the PCI-DAS1602/16, use the SCB-50 signal connection box, CIO-TERM100 screw terminal board, or two CIO-MINI50 screw terminal boards.

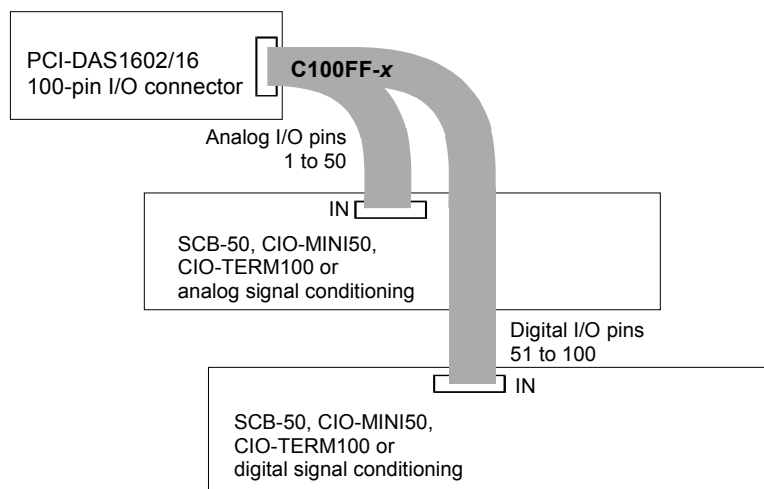


Figure 2-1. Sample wiring configuration using the C100FF-x cable

Programming and Developing Applications

After following the installation instructions in Chapter 2, your board should now be installed and ready for use. Although the board is part of the larger DAS family, in general there may be no correspondence among registers for different boards. Software written at the register level for other DAS models will not function correctly with your board.

Programming languages

Measurement Computing's Universal Library® provides access to board functions from a variety of Windows programming languages. If you are planning to write programs, or would like to run the example programs for Visual Basic® or any other language, please refer to the *Universal Library User's Guide* (available on our web site at <http://www.mccdaq.com/PDFmanuals/sm-ul-user-guide.pdf>).

Packaged applications programs

Many packaged application programs, such as SoftWIRE®, Labtech Notebook™, and HP-VEE™, now have drivers for your board. If the package you own does not have drivers for the board, please fax or e-mail the package name and the revision number from the install disks. We will research the package for you and advise how to obtain drivers.

Some application drivers are included with the Universal Library package, but not with the application package. If you have purchased an application package directly from the software vendor, you may need to purchase our Universal Library and drivers. Please contact us by phone, fax or e-mail:

- Phone: 508-946-5100 and follow the instructions for reaching Tech Support.
- Fax: 508-946-9500 to the attention of Tech Support
- Email: techsupport@measurementcomputing.com

Register-level programming

You should use the Universal Library or one of the packaged application programs mentioned above to control your board. Only experienced programmers should try register-level programming.

If you need to program at the register level in your application, refer to the *Register Map for the PCI-DAS1602/16*. This document is available on our website at www.mccdaq.com/registermaps/RegMapPCI-DAS1602-16.pdf.

Functional Details

The PCI-DAS1602/16 provides the following features:

- 16 single-ended or eight fully differential 16-bit analog inputs
- Two 16-bit analog outputs
- 24-bits, high current digital I/O
- Three 16-bit down counters

PCI-DAS1602/16 functions are illustrated in the block diagram shown here.

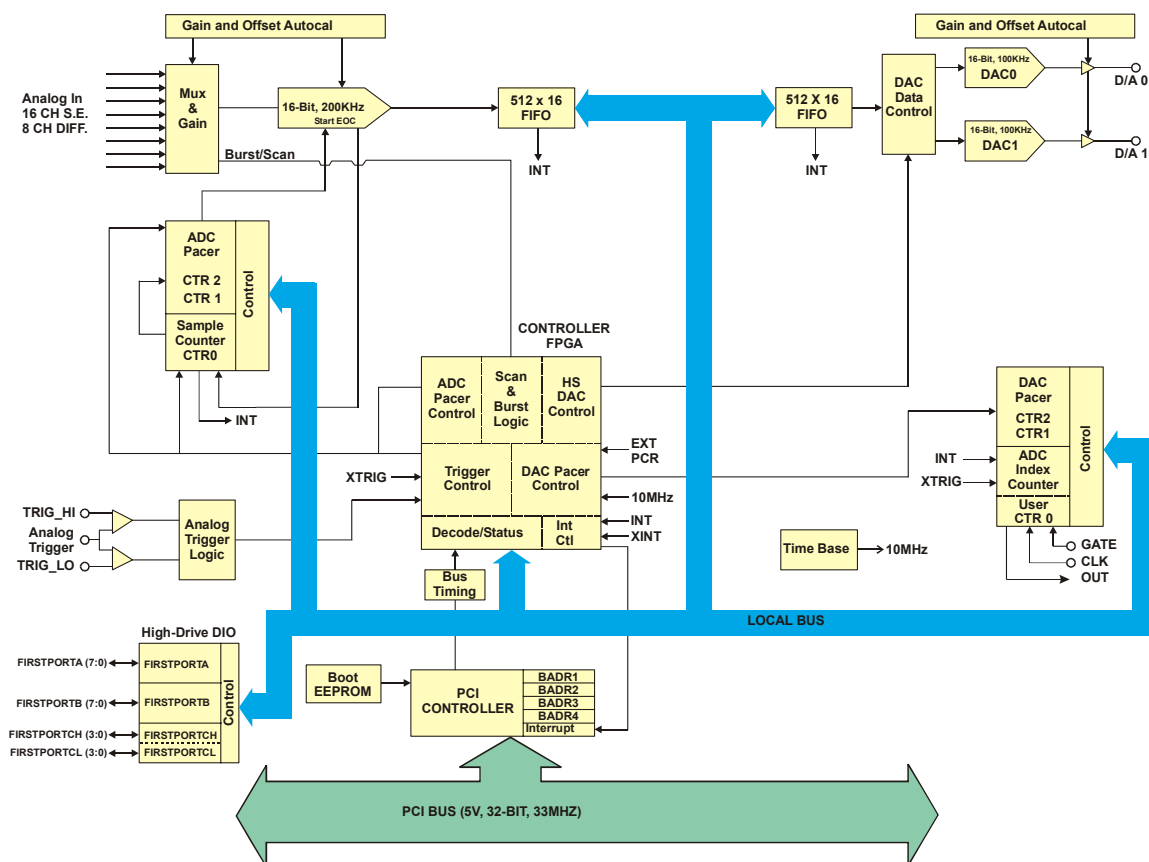


Figure 4-1. PCI-DAS1602/16 Functional Block Diagram

Analog inputs

The analog input mode is software-selectable for eight differential or 16 single-ended analog inputs. The board offers a 200 kHz maximum sample rate in single and multichannel scans at any gain setting. A 512 sample FIFO assures that data taken from the board is transferred into computer memory without the possibility of missed samples. The board has an analog trigger input with software-selectable trigger levels and direction.

Software selects the bipolar/unipolar input configuration and input range. Table 4-4 lists the analog input ranges and resolutions for the available input configurations and gains.

Table 4-4. Input range and resolution

Bipolar Range	Resolution	Unipolar Range	Resolution
$\pm 10\text{V}$	$305\ \mu\text{V}$	0 to 10V	$153\ \mu\text{V}$
$\pm 5\text{V}$	$153\ \mu\text{V}$	0 to 5V	$76.3\ \mu\text{V}$
$\pm 2.5\text{V}$	$76.3\ \mu\text{V}$	0 to 2.5V	$38.1\ \mu\text{V}$
$\pm 1.25\text{V}$	$38.1\ \mu\text{V}$	0 to 1.25V	$19.1\ \mu\text{V}$

Burst mode

Channel-to-channel skew results from multiplexing the A/D inputs. It is defined as the time between consecutive samples. For example, if four channels are sampled at a rate of 1 kHz per channel, the channel skew is $250\ \mu\text{s}$ ($1\ \text{ms}/4$).

Burst mode minimizes channel-to-channel skew by clocking the A/D at the maximum rate between successive channels. Burst mode timing is illustrated in Figure 4-2. At the 1-ms pulse, channel 0 is sampled. After $5\ \mu\text{s}$, channel 2 is sampled. Channel 3 is sampled $5\ \mu\text{s}$ after channel 2 is sampled. No samples are then taken until the next 1-ms pulse, when channel 0 is sampled again. In this mode, the rate for all channels is 1 kHz, but the channel-to-channel skew (delay) is now $5\ \mu\text{s}$, or $20\ \mu\text{s}$ total. The minimum burst mode skew/delay on the PCI-DAS1602/16 is $5\ \mu\text{s}$.

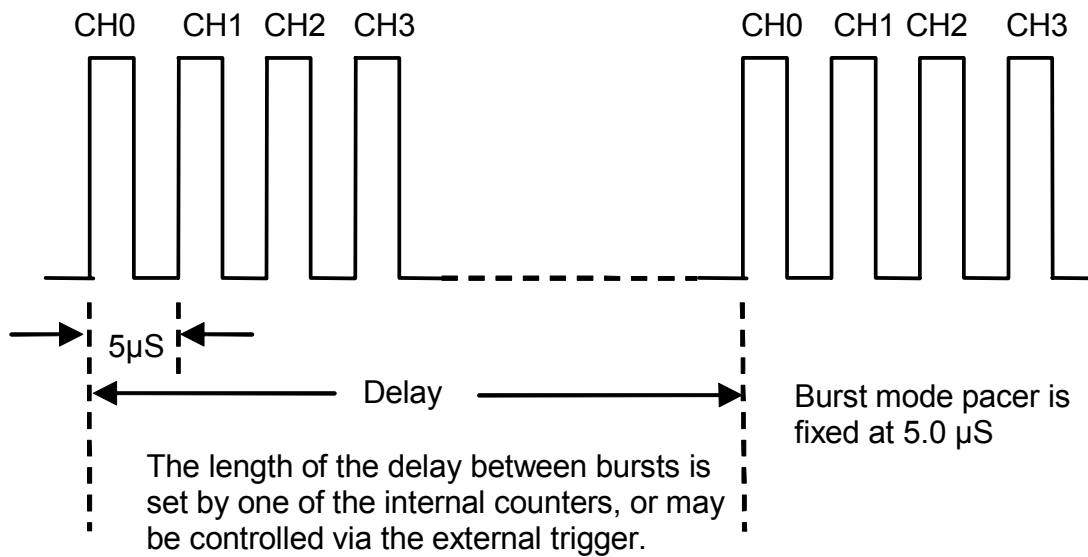


Figure 4-2. Burst mode timing

Analog outputs

The two high-speed 16-bit dual analog outputs are updated via an on-board FIFO and REP OUTSW commands, and provide a 100 kHz maximum update rate. Output ranges are individually configurable with software for $\pm 10\text{V}$ and $\pm 5\text{V}$, 0 to 10V and 0 to 5V. The D/A outputs provide rated accuracy to $\pm 5\ \text{mA}$, and are short circuit protected (25 mA limit). The analog outputs are cleared to 0V on power up or reset.

Parallel digital I/O

The 24 bits of TTL-compatible, high-current (64 mA sink, 15 mA source) digital I/O are available as two eight-bit ports and two four-bit ports. This digital capability is an 82C55 mode 0 chip emulation, allowing each port to be configured independently as either input or output. The digital I/O ports default to the input state (high impedance) on power up or reset.

Counter/timer I/O

The PCI-DAS1602/16 provides two counter 82C54 counter chips. Each chip contains three 16-bit down counters that provide clock, gate, and output connections. You can connect the counter clock to the on-board 10 MHz crystal oscillator, or leave unconnected for user input.

Calibrating the PCI-DAS1602/16

The PCI-DAS1602/16 is equipped with software auto calibration. The *InstaCal* software makes gain and offset corrections to the board using on-board digital potentiometers and trim D/A converters. No user intervention or external equipment is required. The PCI-DAS1602/16 is shipped fully-calibrated from the factory.

All adjustments are made via 8-bit calibration DACs or 7-bit digital potentiometers that are referenced to an on-board factory calibrated standard. Calibration factors are stored on the serial nvRAM. At run time, these calibration factors can be loaded into system memory and can be automatically retrieved when a different DAC/ADC range is specified

You can recalibrate with respect to the factory-measured voltage standards at any time by selecting the **Calibrate** menu in *InstaCal*. Full calibration requires less than two minutes and requires no external equipment or user adjustments.

The standard calibration involves calibrating one channel with 0 volts input (offset), and then with a known input voltage (gain). The PCI-DAS1602/16's on board circuitry first shorts the inputs for offset calibration, then connects the inputs to the ultra-stable precision voltage reference for the gain calibration.

Analog input calibration

Analog inputs are calibrated for offset and gain. Offset calibration is performed directly on the input amplifier with trim DACs acting on the amplifier. Input gain calibration is performed with the precision voltage reference

Front-end offset corrections are typically performed at the gain stage and/or the ADC input. Offset calibration is performed in the instrumentation amplifier gain stage. Front-end gain adjustment is only performed via the ADC reference, since the gain tolerance of the in-amp circuit is quite good, and there is adequate gain tuning range using only the ADC. All calibration values are saved in the serial nvRAM. The analog input calibration system is shown in Figure 5-1.

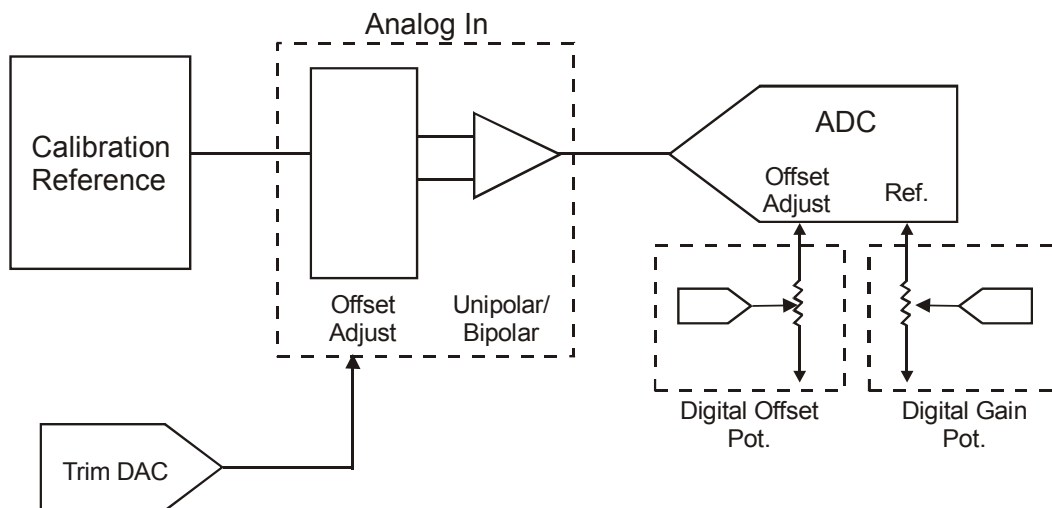


Figure 5-1. Analog input calibration

Analog output calibration

Analog output circuits are calibrated for offset and gain. Coarse and fine offset adjustments are made in the output buffer section. The tuning range of these adjustments allows for maximum DAC and output buffer offsets. Coarse and fine gain calibration is performed via adjustments to the DAC reference.

The analog output calibration system is shown in Figure 5-2. This circuit is duplicated for both DAC0 and DAC1.

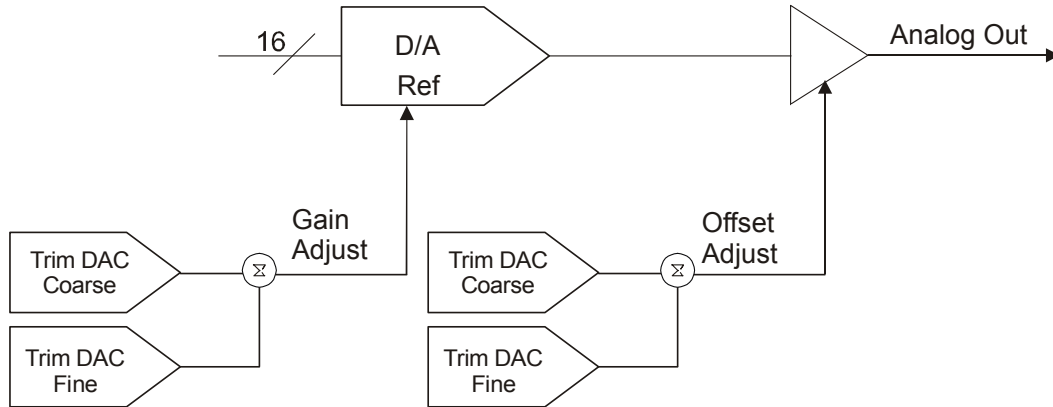


Figure 5-2. Analog output calibration

Specifications

Typical for 25 °C unless otherwise specified.

Specifications in *italic text* are guaranteed by design.

Analog input

Table 6-1. Analog input specifications

A/D converter type	AD976ABN
Resolution	16 bits
Number of channels	16 single-ended / 8 differential, software selectable
Input ranges, software selectable	$\pm 10\text{ V}$, $\pm 5\text{ V}$, $\pm 2.5\text{ V}$, $\pm 1.25\text{ V}$ 0 to 10 V, 0 to 5 V, 0 to 2.5 V, 0 to 1.25 V
Polarity	Unipolar/bipolar, software selectable
A/D pacing (software programmable)	Internal counter - 82C54.
	External source (A/D EXTERNAL PACER)
	Software polled
Burst mode	Software selectable option, rate = 5 μs
A/D trigger sources	External digital (A/D EXTERNAL TRIGGER)
	External analog (ANALOG TRIGGER IN)
A/D triggering modes	External digital: Software configurable for: <ul style="list-style-type: none"> ▪ Edge (triggered) ▪ Level-activated (gated) ▪ Programmable polarity (rising/falling edge trigger, high/low gate)
	External analog: software-configurable for: <ul style="list-style-type: none"> ▪ Positive or negative slope. ▪ Above or below reference ▪ Positive or negative hysteresis ▪ In or out of window
	Trigger levels set by DAC0 and/or DAC1, 4.88 mV resolution.
	Unlimited pre- and post-trigger samples. Total # of samples must be > 256. Compatible with both Digital and Analog trigger options.
Data transfer	From 512 sample FIFO via interrupt w/ REPINSW
	Interrupt
	Software polled
<i>A/D conversion time</i>	<i>5 μs max</i>
Throughput	200 kHz
Calibration	Auto-calibration, calibration factors for each range stored on board in non-volatile RAM.
Common mode range	$\pm 10\text{ V}$ min
CMRR @ 60 Hz	-70 dB
<i>Input leakage current</i>	<i>$\pm 200\text{ nA}$ max</i>
<i>Input impedance</i>	<i>10 MΩ min</i>
<i>Absolute maximum input voltage</i>	<i>$\pm 15\text{ V}$</i>

Accuracy

Table 6-2. Analog input accuracy specifications

Typical accuracy	±2.3 LSB
Absolute accuracy	±5.0 LSB
Accuracy Components	
Gain error	Trimmable by potentiometer to 0
Offset error	Trimmable by potentiometer to 0
<i>PGA linearity error</i>	±1.3 LSB typ , ±10.0 LSB max
Integral linearity error	±0.5 LSB typ , ±3.0 LSB max
Differential linearity error	±0.5 LSB typ , ±2.0 LSB max

Each PCI-DAS1602/16 is tested at the factory to assure the board's overall error does not exceed ±5 LSB.

Total board error is a combination of gain, offset, differential linearity and integral linearity error. The theoretical absolute accuracy of the board may be calculated by summing these component errors. Worst case error is realized only in the unlikely event that each of the component errors is at their maximum level, and causing error in the same direction.

Analog input drift

Table 6-3. Analog input drift specifications

Range	Analog input full-scale gain drift	Analog input zero drift	Overall analog input drift
± 10.00 V	2.2 LSB/°C max	1.8 LSB/°C max	4.0 LSB/°C max
± 5.000 V	2.2 LSB/°C max	1.9 LSB/°C max	4.1 LSB/°C max
± 2.500 V	2.2 LSB/°C max	2.0 LSB/°C max	4.2 LSB/°C max
± 1.250 V	2.2 LSB/°C max	2.3 LSB/°C max	4.5 LSB/°C max
0 - 10.00 V	4.1 LSB/°C max	1.9 LSB/°C max	6.0 LSB/°C max
0 - 5.000 V	4.1 LSB/°C max	2.1 LSB/°C max	6.2 LSB/°C max
0 - 2.500 V	4.1 LSB/°C max	2.4 LSB/°C max	6.5 LSB/°C max
0 - 1.250 V	4.1 LSB/°C max	3.0 LSB/°C max	7.1 LSB/°C max

Absolute error change per °C Temperature change is a combination of the Gain and Offset drift of many components. The theoretical worst case error of the board may be calculated by summing these component errors. Worst case error is realized only in the unlikely event that each of the component errors is at their maximum level, and causing error in the same direction.

Noise performance

The following table summarizes the worst case noise performance for the PCI-DAS1602/16. Noise distribution is determined by gathering 50000 samples with inputs tied to ground at the PCI-DAS1602/16 main connector. Data is for both Single-Ended and Differential modes of operation.

Table 6-4. Noise specifications

Range	±2 counts	±1 count	Max Counts	LSBrms*
± 10.00 V	97%	80%	11	1.7
± 5.000 V	97%	80%	11	1.7
± 2.500 V	96%	79%	11	1.7
± 1.250 V	96%	79%	11	1.7
0 - 10.00 V	88%	65%	15	2.3
0 - 5.000 V	88%	65%	15	2.3
0 - 2.500 V	83%	61%	15	2.3
0 - 1.250 V	83%	61%	16	2.4

* Input noise is assumed to be Gaussian. An RMS noise value from a Gaussian distribution is calculated by dividing the peak-to-peak bin spread by 6.6.

Crosstalk

Crosstalk is defined here as the influence of one channel upon another when scanning two channels at the specified per channel rate for a total of 50000 samples. A full scale 100 Hz triangle wave is input on channel 1. Channel 0 is tied to analog ground at the 100-pin user connector. Table 6-5 summarizes the influence of channel 1 on channel 0 and does not include the effects of noise.

Table 6-5. Crosstalk specifications

Range	1 kHz Crosstalk (LSB pk-pk)	10 kHz Crosstalk (LSB pk-pk)	50 kHz Crosstalk (LSB pk-pk)
±10.000 V	4	13	24
±5.000 V	2	7	18
±2.500 V	2	5	16
±1.250 V	3	4	14
0V to +10.000 V	4	8	23
0V to +5.000 V	2	5	16
0V to +2.500 V	2	4	16
0V to +1.250 V	3	3	16

Analog output

Table 6-6. Analog output specifications

D/A converter type	AD669BR
Resolution	16 bits
Number of channels	2
Channel type	Single-ended voltage output
Output range (each channel independently software selectable)	± 10 V, ± 5 V, 0 to 10 V, or 0 to 5 V
Data transfer	From 512 sample FIFO via REPOUTSW or programmed I/O. Data interleaved for dual analog output mode.
Throughput	100 kHz, 2 channels simultaneous
Monotonicity	16 bits at 25 °C
Slew rate	10 V ranges: 6 V/ μ s
	5 V ranges: 3 V/ μ s
Settling time	13 μ s max 20 V step to 0.0008%
	6 μ s typ 10V step to 0.0008%
Current drive	± 5 mA min
Output short-circuit duration	Indefinite @ 25 mA
Output coupling	DC
Output impedance	0.1 ohms max
Output stability	Any passive load
Coding	Offset binary
Output voltage on power up and reset	0 V \pm 10 mV

Accuracy

Table 6-7. Analog Output Accuracy Specifications

Typical accuracy	± 1 LSB
Absolute accuracy	± 2 LSB
Accuracy Components	
Gain error	Trimable by potentiometer to 0
Offset error	Trimable by potentiometer to 0
Integral linearity error	± 0.5 LSB typ, ± 1 LSB max
Differential linearity error	± 0.5 LSB typ, ± 1 LSB max

Total board error is a combination of gain, offset, differential linearity and integral linearity error. The theoretical absolute accuracy of the board may be calculated by summing these component errors. Worst case error is realized only in the unlikely event that each of the component errors is at their maximum level, and causing error in the same direction.

Analog output drift

Table 6-8. Analog output drift specifications

Analog output full-scale gain drift	± 0.22 LSB/ $^{\circ}\text{C}$ max
Analog output zero drift	± 0.22 LSB/ $^{\circ}\text{C}$ max
Overall analog output drift	± 0.44 LSB/ $^{\circ}\text{C}$ max

Absolute error change per $^{\circ}\text{C}$ temperature change is a combination of the gain and offset drift of many components. The theoretical worst case error of the board may be calculated by summing these component errors. Worst case error is realized only in the unlikely event that each of the component errors is at their maximum level, and causing error in the same direction.

Digital input / output

Table 6-9. Digital input/output specifications

Digital type	82C55 emulation
	Input 74LS244
	Output 74LS373
Number of I/O	24
Configuration	2 banks of 8 and 2 banks of 4, or
	3 banks of 8, or
	2 banks of 8 with handshake
<i>Input high</i>	<i>2.0 volts min, 7 volts absolute max</i>
<i>Input low</i>	<i>0.8 volts max, -0.5 volts absolute min</i>
<i>Output high</i>	<i>2.4 volts min @ -15 mA</i>
<i>Output low</i>	<i>0.5 volts max @ 64 mA</i>
Power-up / reset state	Input mode (high impedance)
Pull-up/pull-down resistors	Provisions have been made on the board for user installed pull-up/pull-down resistor networks
Simultaneous sample and hold trigger	TTL output (SSH OUT). Logic 0 = Hold, Logic 1 = Sample compatible with CIO-SSH16

Interrupts

Table 6-10. Interrupt specifications

Interrupt	INTA# - mapped to IRQn via PCI BIOS at boot-time
Interrupt enable	Programmable through PLX9052
Interrupt polarity	Active high level or active low level, programmable through PLX9052
Interrupt sources (software programmable)	External (rising TTL edge event)
	Residual counter
	A/D End-of-conversion
	A/D End-of-channel-scan
	A/D FIFO-not-empty
	A/D FIFO-half-full
	D/A FIFO-not-empty
	D/A FIFO-half-full

Counter

*Note: Pins 21, 24, and 25 are pulled to logic high via 10K resistors.

Table 6-11. Counter specifications

Counter type	82C54
Configuration	Two 82C54 chips containing three 16-bit down counters each
82C54A:	
Counter 0 — ADC residual sample counter.	Source: ADC Clock.
	Gate: Programmable source.
	Output: End-of-Acquisition interrupt.
Counter 1 — ADC pacer lower divider	Source: 10 MHz oscillator
	Gate: Tied to Counter 2 gate, programmable source.
	Output: Chained to Counter 2 Clock.
Counter 2 — ADC pacer upper divider	Source: Counter 1 Output.
	Gate: Tied to Counter 1 gate, programmable source.
	Output: ADC Pacer clock (if software selected), available at user connector.
82C54B:	
Counter 0 — pretrigger mode	Source: ADC Clock.
	Gate: External trigger
	Output: End-of-Acquisition interrupt.
Counter 0 — non-pretrigger mode: user counter 4	Source: User input at 100pin connector or internal 10MHz (software selectable)
	Gate: User input at 100pin connector.
	Output: Available at 100pin connector.
Counter 1 — DAC pacer lower divider	Source: 10 MHz oscillator
	Gate: Tied to Counter 2 gate, programmable source.
	Output: Chained to Counter 2 Clock.
Counter 2 — DAC pacer upper divider	Source: Counter 1 Output.
	Gate: Tied to Counter 1 gate, programmable source.
	Output: DAC Pacer clock, available at user connector.
<i>Clock input frequency</i>	<i>10 MHz max</i>
<i>High pulse width (clock input)</i>	<i>30 ns min</i>
<i>Low pulse width (clock input)</i>	<i>50 ns min</i>
<i>Gate width high</i>	<i>50 ns min</i>
<i>Gate width low</i>	<i>50 ns min</i>
<i>Input high</i>	<i>2.0 volts min, 5.5 volts absolute max</i>
<i>Input low</i>	<i>0.8 volts max, -0.5 volts absolute min</i>
<i>Output high</i>	<i>3.0 volts min @ -2.5 mA</i>
<i>Output low</i>	<i>0.4 volts max @ 2.5 mA</i>
Crystal oscillator frequency	10 MHz
Frequency accuracy	50 ppm

Power consumption

Table 6-12. Power consumption specifications

+5 V operating (A/D converting to FIFO)	2 A typical, 2.1 A max
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Environmental

Table 6-13. Environmental specifications

Operating temperature range	0 to 70 °C
Storage temperature range	-40 to 100 °C
Humidity	0 to 95% non-condensing

Mechanical

Table 6-14. Mechanical specifications

Card dimensions	PCI custom type card: 107 mm (H) x 18.5 mm (W) x 216 mm (L)
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Main connector and pin out

Table 6-15. Main connector specifications

Connector type	100-pin high-density, Robinson-Nugent
Compatible cables	C100FF-x
Compatible accessory products (with C100FF-x cable)	ISO-RACK16/P ISO-DA02/P BNC-16SE BNC-16DI CIO-MINI50 CIO-TERM100 SCB-50 SSR-RACK24 (DADP-5037 adaptor required) SSR-RACK08 (DADP-5037 adaptor required) CIO-ERB24 (DADP-5037 adaptor required) CIO-ERB08 (DADP-5037 adaptor required)

Table 6-16. 8-channel differential mode

Pin	Signal Name	Pin	Signal Name
1	LLGND	51	FIRSTPORTA Bit 0
2	CH0 HI	52	FIRSTPORTA Bit 1
3	CH0 LO	53	FIRSTPORTA Bit 2
4	CH1 HI	54	FIRSTPORTA Bit 3
5	CH1 LO	55	FIRSTPORTA Bit 4
6	CH2 HI	56	FIRSTPORTA Bit 5
7	CH2 LO	57	FIRSTPORTA Bit 6
8	CH3 HI	58	FIRSTPORTA Bit 7
9	CH3 LO	59	FIRSTPORTB Bit 0
10	CH4 HI	60	FIRSTPORTB Bit 1
11	CH4 LO	61	FIRSTPORTB Bit 2
12	CH5 HI	62	FIRSTPORTB Bit 3
13	CH5 LO	63	FIRSTPORTB Bit 4
14	CH6 HI	64	FIRSTPORTB Bit 5
15	CH6 LO	65	FIRSTPORTB Bit 6
16	CH7 HI	66	FIRSTPORTB Bit 7
17	CH7 LO	67	FIRSTPORTC Bit 0
18	LLGND	68	FIRSTPORTC Bit 1
19	N/C	69	FIRSTPORTC Bit 2
20	N/C	70	FIRSTPORTC Bit 3
21	N/C	71	FIRSTPORTC Bit 4
22	N/C	72	FIRSTPORTC Bit 5
23	N/C	73	FIRSTPORTC Bit 6
24	N/C	74	FIRSTPORTC Bit 7
25	N/C	75	N/C
26	N/C	76	N/C
27	N/C	77	N/C
28	N/C	78	N/C
29	N/C	79	N/C
30	N/C	80	N/C
31	N/C	81	N/C
32	N/C	82	N/C
33	N/C	83	N/C
34	N/C	84	N/C
35	D/A GND 0	85	N/C
36	D/A OUT 0	86	N/C
37	D/A GND 1	87	N/C
38	D/A OUT 1	88	N/C
39	CTR4 CLK	89	GND
40	CTR4 GATE	90	+12V
41	CTR4 OUT	91	GND
42	A/D EXTERNAL PACER	92	-12V
43	ANALOG TRIGGER IN	93	N/C
44	D/A EXTERNAL PACER IN	94	N/C
45	A/D EXTERNAL TRIGGER IN	95	A/D INTERNAL PACER OUTPUT
46	N/C	96	D/A INTERNAL PACER OUTPUT
47	N/C	97	EXTERNAL D/A PACER GATE
48	PC +5V	98	N/C
49	SSH OUT	99	EXTERNAL INTERRUPT
50	GND	100	GND

Table 6-17. 16-channel single-ended mode

Pin	Signal Name	Pin	Signal Name
1	LLGND	51	FIRSTPORTA Bit 0
2	CH0 HI	52	FIRSTPORTA Bit 1
3	CH8 HI	53	FIRSTPORTA Bit 2
4	CH1 HI	54	FIRSTPORTA Bit 3
5	CH9 HI	55	FIRSTPORTA Bit 4
6	CH2 HI	56	FIRSTPORTA Bit 5
7	CH10 HI	57	FIRSTPORTA Bit 6
8	CH3 HI	58	FIRSTPORTA Bit 7
9	CH11 HI	59	FIRSTPORTB Bit 0
10	CH4 HI	60	FIRSTPORTB Bit 1
11	CH12 HI	61	FIRSTPORTB Bit 2
12	CH5 HI	62	FIRSTPORTB Bit 3
13	CH13 HI	63	FIRSTPORTB Bit 4
14	CH6 HI	64	FIRSTPORTB Bit 5
15	CH14 HI	65	FIRSTPORTB Bit 6
16	CH7 HI	66	FIRSTPORTB Bit 7
17	CH15 HI	67	FIRSTPORTC Bit 0
18	LLGND	68	FIRSTPORTC Bit 1
19	N/C	69	FIRSTPORTC Bit 2
20	N/C	70	FIRSTPORTC Bit 3
21	N/C	71	FIRSTPORTC Bit 4
22	N/C	72	FIRSTPORTC Bit 5
23	N/C	73	FIRSTPORTC Bit 6
24	N/C	74	FIRSTPORTC Bit 7
25	N/C	75	N/C
26	N/C	76	N/C
27	N/C	77	N/C
28	N/C	78	N/C
29	N/C	79	N/C
30	N/C	80	N/C
31	N/C	81	N/C
32	N/C	82	N/C
33	N/C	83	N/C
34	N/C	84	N/C
35	D/A GND 0	85	N/C
36	D/A OUT 0	86	N/C
37	D/A GND 1	87	N/C
38	D/A OUT 1	88	N/C
39	CTR4 CLK	89	GND
40	CTR4 GATE	90	+12V
41	CTR4 OUT	91	GND
42	A/D EXTERNAL PACER	92	-12V
43	ANALOG TRIGGER IN	93	N/C
44	D/A EXTERNAL PACER IN	94	N/C
45	A/D EXTERNAL TRIGGER IN	95	A/D INTERNAL PACER OUTPUT
46	N/C	96	D/A INTERNAL PACER OUTPUT
47	N/C	97	EXTERNAL D/A PACER GATE
48	PC +5V	98	N/C
49	SSH OUT	99	EXTERNAL INTERRUPT
50	GND	100	GND

EC Declaration of Conformity

We, Measurement Computing Corporation, declare under sole responsibility that the product

PCI-DAS1602/16

High speed analog I/O board for the PCI bus

Part Number

Description

to which this declaration relates, meets the essential requirements, is in conformity with, and CE marking has been applied according to the relevant EC Directives listed below using the relevant section of the following EC standards and other informative documents:

- EU EMC Directive 89/336/EEC: Essential requirements relating to electromagnetic compatibility.
- EN 55022 Class B (1995): Radiated and conducted emission requirements for information technology equipment.
- ENV 50204 (1995): Radio-frequency electromagnetic field immunity.
- EN 55024 (1998): EC generic immunity requirements.
- EN50082-1 (1997): EC generic immunity requirements.
- EN 61000-4-2 (1995): Electrostatic discharge immunity.
- EN 61000-4-3 (1997) ENV 50204 (1996): RF immunity.
- EN 61000-4-4 (1995): Electric fast transient burst immunity.
- EN 61000-4-5 (1995): Surge immunity.
- EN 61000-4-6 (1996): Radio frequency common mode immunity.
- EN 61000-4-8 (1994): Power frequency magnetic field immunity.
- EN 61000-4-11 (1994): Voltage dip and interrupt immunity.

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